REMARKS

This amendment is responsive to the Office Action of October 23, 2006. Examination and allowance of new claims 10-23 are requested.

The Office Action

The Examiner objected to the specification and claims under 35 U.S.C. § 132(a) and 35 U.S.C. § 112, first paragraph, as adding new matter.

Prior claims 1, 8, and 9 were rejected under 35 U.S.C. § 102 as being anticipated by Chandler (US 5,860,931).

Claims 2-7 stand rejected under 35 U.S.C. § 103 as being unpatentable over Chandler in view of Cesmeli ("An Automated Temporal Alignment Technique For the Translation and Rotational Correction of Digital Radiographic Images", Bjork-Shiley Heart Valves).

New Matter

The applicants have removed the amendments to the specification to which the Examiner objected. The prior claims have been cancelled and replaced with claims which are fully supported by the specification.

The Present Application

The present application is directed to a method of visualizing perfusion of an organ. For example, a patient is injected with a contrast agent and a series of magnetic resonance images are generated. The contrast agent is selected as one which both perfuses through a membrane or other tissue of interest and is readily identifiable in a magnetic resonance image. By watching the distribution of the contrast image over time in a series of magnetic resonance images, the rate at which the contrast agent perfuses through the membrane of each cell or other tissue of interest can be determined. This diffusion rate is indicative of various medical conditions. For example, dead or badly diseased cells may have no uptake of the contrast agent while, normal, healthy cells will have an uptake of the contrast agent at a rate which is generally associated with such healthy cells.

Because perfusion images are taken over a relative long time, there is typically patient movement, such as respiratory movement under which the chest cavity expands and contracts. In an image through the torso of a patient lying in his/her back, the spine remains still while the organs near the lungs are displaced. Thus, portions of the image move and portions do not. The inventors propose to define a reference region in the immediate vicinity of the organ of interest and track the rotational and translational movement of that region of interest. Specifically, the present application proposes to determine a transform for each image of the series which transform transforms the position of the reference region to the same postion as the reference region in a preceding image. In one embodiment, the preceding image is the immediate preceding image. In another embodiment, the reference image is the first image of the series.

Once this transform of the reference region is determined, it is applied to the entire image. It should be noted that this transform will cause portions of the image which had been stationary, such as the spine, to move from image to image with respiratory motion. Similarly, other areas outside of the reference region may also move from image to image. But, the reference region of the organ is held stationary.

By keeping the reference region stationary, the movement or perfusion of the contrast agent in the organ can be readily tracked from image to image simplifying perfusion measurements.

<u>The References of Record</u>

Chandler is directed to an ultrasound method and system for measuring perfusion. In ultrasound, perfusion is measured differently than in x-ray or MR imaging. As Chandler notes at column 9, lines 59-62, in ultrasound scanning to prepare data for an image is very different from scanning to conduct perfusion measurements. The two cannot be run simultaneously.

In ultrasound perfusion imaging, an ultrasound beam is used to destroy contrast agents everywhere within a perfusion box selected by the user (column 9, lines 64-67). Then, the ultrasound beam is used to interrogate small or incremental regions of interest that cover the perfusion box (column 10, lines 2-4). Rather than

destroying the contrast agent, one can also use an activatable contrast agent (column 10, lines 13-15). In either technique, the ultrasound beam is focused on incremental areas within the defined box to measure a rate of change of contrast agent presence within each incremental area (column 10, lines 19-46).

As the Examiner notes, at column 10, lines 66-67, Chandler discloses that tissue may move and that the movement of the tissue should be tracked. However, this tracking is not done by transforming regions of a series of images. Rather, the tracking is performed as described in US Application Serial No. 08/916,358 (now US 4,691,702) (column 11, lines 7-8). This technique tracks the position of a tissue of interest surface (column 11, lines 8-13). It is submitted that this measurement is more in the nature of a ranging in measurement which measures cyclic movement of a surface and is not an image based technique. Moreover, the movement in Chandler would be used to adjust the perfusion data acquisition such that the next collected perfusion data is collected from the same box or incremental region in each echo. There is no image or image transform suggested.

It should be noted that ultrasonic images are relatively slow, made slower by the need to perform a separate perfusion measurement sequence using the same transducers.

Again, Chandler makes no suggestion of generating a series of ultrasound images, aligning regions of those images, and drawing perfusion behavior out of such images. Rather, Chandler indicates that it is necessary to perform separate imaging and perfusion measurement sequences.

Cesmeli is directed to an alignment technique for a series of digital radiographic images. First, it is submitted that there is no enabling disclosure in Cesmeli or Chandler which would provide any guidance to the reader regarding how one could integrated digital radiographic imaging techniques with the described ultrasound imaging techniques.

Moreover, the Cesmeli technique would be inappropriate for use to track tissue movement in Chandler. First, in order to track the tissue surface movement in substantially real-time so that it can be used to guide the perfusion data acquisition, the two techniques would need to be performed concurrently on the same region of the patient. This would raise radiation exposure issues regarding the technician

performing the ultrasound method and the ultrasound imaging equipment could cause artifacts in the x-ray digital images.

Second, Cesmeli is not held out to be a real-time alignment technique. Rather, it is submitted that the intense processing that the Cesmeli technique needs would have relegated it to a post-processing technique. Thus, the Cesmeli technique would have been unsuited for real-time guidance of an ultrasonic perfusion measurement.

Cesmeli aligns the central axes of the valves. While this may sound simple, the valves do not come with their central axes labeled or denoted in the images. Rather, a complex operation is needed, as described by Cesmeli, to determine the axis. This operation includes filtering, thresholding, and segmentation. In the segmentation step, one is effectively determining the surface which separates the interior of blood passage chambers or regions of the heart from the heart muscle itself. As Cesmeli indicates, this is a rather elaborate process. If the cardiac volume that is defined by the segmentation is the left ventricle, then the region is generally an ellipsoid which would have a mathematically defined centroid. Of course, various other operations are described in Cesmeli in order to accurately define the axis of the valve and generate images of the valve in a plane orthogonal to the defined axis. After this is done, then rotational alignment is performed.

The Chandler and Cesmeli references are incompatible. The two techniques use different equipment which generates materially different data sets, which are processed in materially different ways for materially different purposes. There is no motivation or enablement provided in either Cesmeli or Chandler for combining these two references.

The Examiner asserts that Chandler teaches using autocorrection methods to perform translation and rotation. The applicants disagree. Rather Cesmeli uses ultrasound to monitor cyclic movement of a tissue surface. This makes no suggestion of rotational and translational correction. Moreover, this measurement is used to adjust or correct the collection of perfusion data, not to align sequential images.

One cannot merely plug the ultrasound echo data of Chandler into Cesmeli. The techniques and the nature of the data which they generate are just too different.

The Claims Distinguish Patentably Over the References of Record

The new claims have been carefully drafted to distinguish patentably and unobviously over the references of record.

CONCLUSION

For the reasons set forth above, it is submitted that claims 10-23 distinguish patentably and unobviously over the references of record and meet all statutory requirements. An early allowance of all claims is requested.

In the event the Examiner considers personal contact advantageous to the disposition of this case, he is requested to telephone Thomas Kocovsky at (216) 861-5582.

Respectfully submitted,

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